SECTION 8.00
STORM DRAINAGE

8.01 STORM DRAINAGE MATERIALS

A. Pipe Materials

1. Reinforced Concrete Pipe shall be as per ASTM C76, Table III or Table IV with a minimum 15 inch **(18 inch minimum in public rights-of-way)** inside diameter. Joints shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant.

2. Corrugated Steel Pipe or Pipe-Arch shall have a minimum 15 inch **(18 inch minimum in public rights-of-way)** nominal diameter and conform to AASHTO M36 with pipe ends having no less that 2 round corrugations on each end. Bands for connecting pipes shall be coated and corrugated with a minimum of 2 corrugations for each pipe. Pipe shall be fully bituminous coated with an asphalt paved invert in accordance with the requirements of AASHTO M190 for Type C pipe **except for pipe used in a detention (dry) pond.**

3. **High Density Polyethylene (HDP) Corrugated Storm Sewer Pipe** shall have a minimum 15 inch nominal diameter and shall be used in areas outside of public rights- of- way. **HDP pipe may be used in the public right-of-way but must be approved prior to installation by the City Engineer or their designee. No less than 18" pipe size will be allowed public rights-of-way.** High Density Polyethylene Corrugated Storm Sewer Pipe shall be installed **according to the manufactures specifications**. Pipe material shall meet the product specifications of ASTM F667 and shall have a smooth interior.

B. Structure Materials

All storm drainage structures such as manholes, inlets, junction boxes and catch basins shall be constructed of either solid brick, solid block, or precast concrete.

1. Clay Brick shall be solid, rough, sound clay brick conforming to ASTM C32, Grade MS. The brick shall be laid with full shove joints, filling up the joints with mortar. The thickness of the joints shall not exceed 3/8 of an inch.

2. Concrete Block or brick shall be solid and conform to ASTM C139 as to design and manufacture. The block or brick shall be embedded in a mortar bed to form a 1/2 inch mortar joint.

3. Precast Concrete Manholes shall meet ASTM C478 as to design and manufacture. All manhole cones shall be the eccentric type. Manhole joints

shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant.

4. Manhole Frames and Covers shall be cast iron or ductile iron with "Storm Sewer" stamped on the cover and two 1 inch holes. Castings shall be machined to give even and continuous bearing on the full length of the frame. Castings shall be free of porosity and blow holes, and shall receive one coat of Koppers Super Service Bitumastic black paint **or equal**. Paint shall be kept off of bolt threads, and surfaces shall be thoroughly wire brushed before painting. All manhole rings in roadways shall be installed in accordance with **Standard Detail 8.05**.

5. Manhole Steps shall be of polypropylene material reinforced with a 1/2 inch diameter reinforcing rod. They shall be designed for a vertical load of 400 pounds and a horizontal pullout load of 1000 pounds, and shall be set 16" on center. Holes for the installation of manhole steps shall not project through the manhole wall, but shall stop a minimum of one inch from the outside wall. Steps shall be at least 10 inches clear width and shall project at least 4 inches from the wall into which they are embedded. Steps in precast concrete structures shall be installed by the manufacturer.

6. Catch Basins (curb inlets) for street drainage shall be in accordance with Standard Detail 8.03 or 8.04. Precast concrete boxes are allowed, but precast manholes are not acceptable for use as catch basins. All catch basin grates shall be the bicycle safe type.

7. Headwalls and Endwalls may be cast in place per NCDOT Standard Details 838.01 through 838.75, or precast with wing walls and apron by an approved manufacturer. Installation of precast headwalls and endwalls shall be in accordance with the manufacturer's recommended installation procedures and specifications.

8.02 STORM SEWERS

A. Location

1. All public storm sewers shall be installed in dedicated street right of way or dedicated storm sewer easements. Minimum widths of storm sewer easements shall be 20 feet for pipes up to and including 48 inches in diameter and 30 feet for pipes greater than 48 inches in diameter.

2. See Sections 6.00 and 7.00 for horizontal and vertical separation requirements between storm drainage pipe, water lines, and sanitary sewer lines.

3. The City of Asheville shall maintain only the storm sewer systems within City maintained rights of way and on City owned property, unless an easement has previously been offered and maintenance responsibility accepted by the City.

Storm drainage systems located on private property shall be maintained by the property owner(s).

4. Unless prevented by topographic constraints, storm sewer systems shall not discharge into front yards of lots, but shall extend to within 20 feet of the rear property line in lots up to 1/2 acre in size and shall extend a minimum of 150 feet from right of way in lots larger than 1/2 acre.

5. Pipes, drains, flumes or other concentrated stormwater devices shall not discharge across a sidewalk, but rather shall be piped or flumed under the sidewalk.

B. <u>Sizing and Design</u>

1. Storm sewer systems shall be designed on the basis of the 10 year storm for inlet spacing, the 25 year storm for street drainage pipe sizing, the 50 year storm for cross-street drainage, and the 100 year storm for flood plain areas. Pipes shall be designed to flow 7/8 full.

2. Runoff rates shall be calculated by the Rational Method, SCS Method, or other acceptable procedure. Runoff computations shall be based on rainfall data published by the National Weather Service for this area.

3. For drainage areas of 200 acres or less, the Rational Method is recommended to calculate runoff. For drainage areas greater than 200 acres, the SCS Method or other recognized method is recommended.

4. Time of concentration (tc) shall be appropriate for the drainage area in question using Kirpich Equation (Bureau of Reclamation, 1974, p.71).

5. Storm duration shall equal the time of concentration (tc).

6. Storm sewer pipe shall be sized in accordance with the Manning Equation.

7. Storm sewers shall be designed to provide a velocity of at least 2 feet per second at design flow.

8. The minimum pipe diameter shall be 15 inches.

C. <u>Installation</u>

1. All storm sewers shall be installed to provide a true line and grade between structures.

2. Structures shall be installed at each deflection of line and/or grade.

3. **The maximum length between access points shall be 250 feet for pipe sizes of 15 inches to 42 inches and 300 feet for pipe sizes greater than 48 inches in diameter.**

4. No inaccessible storm drainage structures shall be allowed.

5. Pipe may enter through the corner of all structure material types except precast concrete "waffle" boxes.

6. A reinforced concrete slab designed by an engineer may be used at oversized structures to adjust an inlet to standard dimensions.

7. The minimum cover for storm sewer pipe shall be 2 feet to finished subgrade under roads and 1 foot to finished grade under nonload-bearing areas **or as approved by the City Engineer.** Trench excavation and backfilling shall be in accordance with Section 5.00 of these specifications.

8. Pipe shall not project into a drainage structure but shall be finished flush with the inside of the structure.

9. Catch basins between 5 and 20 feet in depth shall have minimum interior dimensions of 4 feet by 4 feet, and those over 20 feet in depth shall have minimum interior dimensions of 5 feet by 5 feet.

10. Each drainage structure shall have a shaped invert constructed from concrete, and a bench with a maximum 5:1 slope. The bench shall begin at a height of one-half the pipe diameter for 15 to 24 inch pipe, one-third the pipe diameter for 30 to 48 inch pipe, and one-fourth the diameter for pipe greater than 48 inches in diameter.

11. Precast concrete structures may be installed only to depths certified as acceptable by the manufacturer.

D. <u>Pipe Inlets and Outlets</u>

1. Headwalls, endwalls or flared end sections shall be installed at all inlets and discharge points.

2. Flared end sections shall be installed on single pipe culverts up to and including 60 inches in diameter, and on multiple pipe culverts up to and including 36 inches in diameter.

3. Headwalls and endwalls shall be installed on single pipe culverts greater than 60 inches in diameter, and on multiple pipe culverts greater than 36 inches in diameter.

4. Precast headwalls shall only be installed at single pipe culverts.

5. Energy dissipaters shall be installed at all discharge points and shall be properly sized to ensure that stormwater is released at a nonerosive velocity.

6 A fabric or washed stone barrier shall be installed between the dissipation pad and the natural ground.

7. The stormwater design shall include scour protection for the drainage way.

8. Storm drainage channels and ditches shall be designed to carry the design flow at nonerosive velocities. Calculations indicating design velocities shall be provided along with typical channel cross-sections. The maximum allowable design velocity in grass channels is 4 feet per second.

9. The Engineering Department may require additional information on the impact of stormwater discharge on adjacent properties.

E. <u>Street Drainage</u>

1. Stormwater shall not be allowed to flow across streets at intersections. Drainage structures shall be provided to intercept flow prior to the radius of intersections or the street design shall provide for a continuous grade around the radius to channel flow down the intersecting street.

2. No stormwater inlets shall be placed within travel areas of a roadway or parking lot unless design cannot accommodate relocation in which cases the City Engineer must approve.

3. Curb inlets shall be designed to intercept stormwater before the gutter spread exceeds 8 feet for the 2 year storm. In areas of heavy pedestrian traffic, the maximum allowable spread may be decreased by the City Engineer.

F. <u>Determination of Runoff Quantities</u>

Runoff quantities shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel under development. The quantity of runoff which is generated as the result of a given rainfall intensity may be calculated as follows:

1. For areas up to and including 200 acres the Rational Method may be used. In the Rational Method, the peak rate of runoff, Q, in cubic feet per second is computed as:

$$Q = CIA$$

where: C = runoff coefficient, representing the characteristics of the drainage area and defined as the ratio of runoff to rainfall;

I = average intensity of rainfall in inches per hour for a duration equal to the time of concentration (tc) for a selected rainfall frequency;

A = tributary drainage area in acres.

Guidance to selection of the runoff coefficient "C" is provided by Table 1 which shows values for different types of surface and local soil characteristics. The composite "C" value used for a given drainage area with various surface types shall be the weighted average value for the total area calculated from a breakdown of individual areas having different surface types.

TABLE 1

Urban Runoff Coefficients

TYPES OF SURFACE	RUNOFF COEFFICIENT "C"
Asphalt	0.82
Concrete	0.85
Roof	0.85
Lawns (Sandy)	
Flat (0-2% Slope)	0.07
Rolling (2-7% Slope)	0.12
Steep (greater than 7%0 slope)	0.17
Lawns (Clay)	
Flat (0-2% Slope)	0.16
Rolling (2-7% Slope)	0.21
Steep (greater than 7%)	0.30

Table 2 provides runoff coefficients and inlet times for different land use classifications. In the instance of undeveloped land situated in an upstream area, a coefficient or coefficients shall be used for this area for its present state of zoning classification.

Rainfall intensity shall be determined from the rainfall frequency curves. The time of concentration (tc) to be used shall be the sum of the inlet time and flow time in the drainage facility from the most remote part of the drainage area to the point under consideration. The flow time in the storm sewers may be estimated by the distance in feet divided by velocity of flow in feet per second. The velocity shall be determined by the Manning Formula. Inlet time is the combined time required for the runoff to reach the inlet of the storm sewer. It includes overland flow time and flow time through established surface drainage channels such as swales, ditch and sheet flow across such areas as lawns, fields and other graded surfaces.

2. The runoff rate for areas in excess of 200 acres can be determined by the SCS method, hydrograph techniques and/or computer modeling.

TABLE 2

Runoff Coefficients "C" By Land Use And Typical Inlet Times

Land-Use	Runoff Coefficients			Inlet Times
Commercial	0.75	0.83	0.91	5
Industrial	0.63	0.70	0.77	5-10
Garden Apartments	0.54	0.60	0.66	
Churches	0.54	0.60	0.66	
Schools	0.31	0.35	0.39	10-15
Semi-Detached Residential	0.45	0.50	0.55	
Detached Residential	0.40	0.45	0.50	
Quarter Acre Lots	0.36	0.40	0.44	
Half Acre Lots	0.31	0.35	0.39	

1. Flat terrain 0-2% slopes.
2. Rolling terrain 2-7% slopes.
3. Steep terrain greater than 7% slopes.
4. Interpolation, extrapolation and adjustment for local conditions shall be based on engineering experience and judgment.
5. The coefficients of this tabulation are applicable to storms of 10 year frequency.

G. Underground or Parking Lot Storage

If surface basins are not feasible, underground or parking lot storage may be necessary. Underground storage can be accomplished by installation of a storage facility under a parking or grassed area. This area shall be required to have appropriate access to allow for its maintenance. The storage facility shall also be required to have all joints properly sealed to prevent undermining of the structures.

When storage is used within a pipe system all pipes shall have sealed joints. The use of o-rings on reinforced concrete or neoprene gaskets for coupling on corrugated metal pipe are necessary. The minimum slope on any underground storage structure is 0.5%.

H. Location Consideration

It should be noted that the location of storage facilities is very important as it relates to the effectiveness of these facilities to control downstream flooding. Small facilities will only have minimal flood control benefits and these benefits will quickly diminish as the flood wave travels downstream. Multiple storage facilities located in the same drainage basin will affect the timing of the runoff through the conveyance system which could decrease or increase flood peaks in different downstream locations. Thus it is important for the designer to design storage facilities both as drainage structures controlling runoff from a defined area and as facilities that will interact with other drainage structures within the drainage basin.

I. Dam Safety Act

Under the Dam Safety Act regulations, a dam is an artificial barrier that does or may impound water and that is 15 feet or greater in height and has a maximum storage volume of 10 acre-feet or more. A number of exemptions are allowed from the Safe Dams Act and any questions concerning a specific design or application should be addressed to the North Carolina Department of Environment, Health, and Natural Resources, Dam Safety Section of Land Resources (919-733-4574).

J. Storm Sewer Plan Design and Construction Standards

All storm sewers, whether private or public, and whether constructed on private or public property shall conform to the design standards and other requirements contained herein. When adequate storm drainage is provided by means of approved pipe installation and the necessary easements to provide access obtained and conveyed to the City, the City shall assume responsibility for maintenance.

1. Manning Equation:

   The hydraulic capacity of storm sewers shall be determined using Manning Equation:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

V = Mean velocity of flow in feet per second

R = the hydraulic radius in feet

S = the slope of the energy grade line in feet per foot.

n = roughness coefficient

The hydraulic radius, R, is defined as the cross sectional area of flow divided by the wetted flow surface or wetted perimeter. Typical "n" values and maximum permissible velocities for storm sewer materials are listed in Table 3.

2. Minimum Size:

The minimum size of all storm sewers shall be 15-inches and capable of handling the 10 year 24-hour storm frequency.

TABLE 3

Typical Values of Manning's n

Material	Manning's **n**
Closed Conduits	
HDP	**0.011**
Concrete	0.013
Cast Iron	0.013
CMP	*****
Open Channels	
Concrete, Trowel Finish	0.013
Concrete, Broom or Float Finish	0.015
Gunite	0.018
Rip Rap Placed	0.035
Rip Rap Dumped	0.035
Gabion	0.028
New Earth (Uniform, Sodded, Clay)	0.025
Existing Earth (Fairly	

Uniform, with some Weeds)	0.030
Dense Growth of Weeds	0.040
Dense Weeds and Brush	0.040
Swale with Grass	0.035

*** As Outlined in the "Handbook of Steel Drainage and Highway Construction Products."**

3. Grade

Sewer grade shall be such that in general, a minimum of one and one half feet of cover is maintained over the top of the pipe. Pipe cover less than the minimum may be used only upon approval from the City Engineer. Uniform slopes shall be maintained between inlets, manholes and inlets to manholes. Final grade shall be set with full consideration of the capacity required, sedimentation problems and other design parameters. Minimum and maximum allowable slopes shall be those capable of producing velocities of 3 feet per second and 15 feet per second, respectively, when the sewer is flowing full**. A minimum of five tenths percent (0.5%) grade for self cleaning must be provided.**

4. Alignment

Storm sewers shall be straight between manholes. Where long radius curves are necessary to conform to street layout, the minimum radius of curvature shall be no less than 100 feet for sewers 42 inches and larger in diameter. Deflection of pipe sections shall not exceed the maximum deflection recommended by the pipe manufacturer. The deflection shall be uniform and finished installation shall follow a smooth curve.

5. Manholes

Manholes shall be installed to provide access to continuous underground storm sewers for the purpose of inspection and maintenance. Precast concrete manholes shall have a monolithic extended concrete base. Manhole shall have minimum 5-inch wall thickness and be constructed of four thousand (4,000) psi concrete. Inverts shall be formed to provide a definite channel of flow through the structure. Manholes shall be provided at the following locations:

1. Where two or more storm sewers converge.

2. At the point of beginning or at the end of a curve, and at the point of reverse curvature.

3. Where pipe size changes.

4. Where an abrupt change in alignment occurs.

5. Where a change in grade occurs.

6. At suitable intervals in straight sections of sewer.

The maximum distance between storm sewer manholes shall be as follows:

Size of Pipe (diameter in inches)	Maximum Distance (feet)
15 through 42	300
48 and larger	400

6. Inlets

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey it to storm sewers, channels or culverts. Curb inlets shall be located such that the gutter flow spread does not exceed 8 feet or 1/3 of the street width, whichever is less, during a 10 year storm event with a minimum spacing of 400 feet. Curb inlets shall be located at all low points to prevent ponding water. Curb inlets shall be located on the upstream sides of intersecting streets to prevent flow a cross the intersecting street. No curb inlets shall be constructed in the radius of curbing at intersections.

7. Special Hydraulic Structures

Special hydraulic structures required to control the flow of water in storm runoff drainage systems include junction chambers, drop manholes, inverted siphons, stilling basins, and other special structures. The use **of** these structures shall be limited to those locations justified by prudent planning and by careful and thorough hydraulic engineering analysis and approved by the City.

8. Easements

For underground storm drain pipe the minimum width of the easement shall be 20 feet for pipe sizes up to and including 48 inches in diameter and 30 feet for pipe sizes greater than 48 inches in diameter.

9. Bedding

Excavation for storm drainage pipe shall be to the lines and grades as shown on the plans. The bedding shall provide a firm foundation uniform density along the entire length of pipe.

Where unstable soils are encountered, a minimum 6-inch thick bedding of stone shall be placed. The stone shall be uniformly graded from 3/4-inch to No. 4 in accordance with ASTM C-33. Care shall be taken to prevent undercutting in suitable soil.

K. Open Channel Design Standards:

All open channels, whether private or public, and whether constructed on private or public land, shall conform to the design standards and other design requirements contained herein. Open channels shall be capable of handling the 10 year storm frequency. Where adequate storm drainage is provided by means of properly constructed and graded channels or ditches the maintenance thereof will remain the responsibilities of the property owner and must be so noted on the final plat and the deed for the affected lots.

1. Manning Equation

The waterway for channels shall be determined using Manning's Equation.

$$Q = AV = A\,\frac{1.486}{n}\,R^{2/3}\,S^{1/2}$$

A = Waterway area of channel in square feet.
Q = Discharge in cubic feet per second (cfs)

2. Channel Cross Section and Grade

The required channel cross section and grade are determined by the design capacity, the material in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for sub-surface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation but low enough to prevent erosion. Velocities less than 1.5 feet per second should be avoided since siltation will take place and ultimately reduce the channel cross section. The maximum permissible velocities in vegetal-lined channels are shown in Table 4. Developments through which the channel is to be constructed must be considered in design of the channel section.

3. Side Slopes

   Earthen channel side slopes shall be no steeper than 2 to 1. Flatter slopes may be required to prevent erosion and for ease of maintenance. Where channels will be lined, side slopes shall be no steeper than 1 1/2 to 1 with adequate provisions make for weep holes. Side slopes steeper than 1 1/2 to 1 may be used for lined channels provided that the side lining is designed and constructed as a structural retaining wall with provisions for live and dead load surcharge.

4. Channel Stability

   1. Characteristics of a stable channel are:

      a. It does not degrade beyond tolerable limits.

      b. The channel banks do not erode to the extent that the channel cross section is changed appreciably.

      c. Excessive sediment bars do not develop.

      d. Excessive erosion does not occur around culverts, bridges or elsewhere.

TABLE 4

MAXIMUM PERMISSIBLE VELOCITIES IN LINED CHANNELS (1)

		PERMISSIBLE VELOCITY 1/	
Cover	Slope range 2/ (percent)	Erosion Resistant Soils (ft. per sec)	Easily Eroded Soils (ft. per sec)
Bermuda grass	0-5 5-10 over 10	8 7 6	6 5 4
Bahia Buffalo grass Kentucky Bluegrass Smooth Brome Blue Grama	0-5 5-10 over 10	7 6 5	5 4 3
Grass Mixtures Reed Canary grass	2/ 0-5 5-10	5 4	4 3
Lespediza Sericea Weeping Lovegrass Yellow Bluestem Redtop Alfalfa Red Fescue	3/ 0-5	3.4	2.5
Common Lespedeza 4/ Sudan grass 4/	5/ 0-5	3.5	2.5

1/ Use velocities exceeding 5-feet per second only where good covers and proper maintenance can be obtained.

2/ Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

3/ Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

4/ Annuals -- use on mild slopes or as temporary protection until permanent covers are established.

5/ Use on slopes steeper than 5 percent is not recommended.

e. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

1. Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bank full flow, whichever is greater, using an "n" values for various channel linings are shown in Table 3.

2. Channel stability must be checked for conditions immediately after construction. For this stability analysis the velocity shall be calculated for the expected flow from a ten-year frequency storm on the water shed. The allowable velocity in the newly constructed channel may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

3. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

4. Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are shown.

5. The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

6. Appurtenant Structures

The design of channels shall provide for all structures required for the proper functioning of the channel and the laterals thereto and travel ways for operation and maintenance. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design is also to provide for necessary flood gates, water level control devices, and any other appurtenance affecting the functioning of the channels and the attainment of the purpose for which they are built. The effect of channel improvements on existing culverts, bridges, buried cables, pipelines and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement.

Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge.

7. Disposition of Spoil

Spoil material resulting from clearing, grubbing and channel excavation shall be disposed in such a manner which will:

1. Minimize over bank wash.

2. Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.

3. Not hinder the development of travel ways for maintenance.

4. Leave the right-of-way in the best condition feasible, consistent with the project purposes, for productive use by the owner.

5. Improve the aesthetic appearance of the site to the extent feasible.

8. <u>Construction and Materials</u>

a) Construction

Specifications shall be in keeping with the proceeding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

b) Materials

Materials acceptable for use as channel lining are:

1. Grass

2. Revetment Rip rap

3. Concrete

4. Hand-laid Rip rap

5. Pre-cast Concrete Rip rap

6. Grouted Rip Rap

7 Gabions

8 Erosion Control Blankets

c. Easements

Where open improved drainage channels are used, the width of the easement shall be a minimum of 3 feet on one side measured at the intersection of the existing ground and channel cut plus the width of the channel at the top or ground level plus 10 feet on the opposite side to allow equipment to enter for maintenance operations.

L. <u>Plan Submittals</u>

Site plans shall be submitted for review and approval and shall include:

1. Descriptive Information:

A. Title Block With:

1. Development Name

2. Owner

3. Design Firm

4. Authorized Registered Professional Engineer or Landscape Architect or Architect's signature and date.

5. Legend

6. North Arrow

7. Vicinity Map

8. Scale

9. Sheet Numbers

10. Date

11. Revision Numbers and Dates

B. Topographical Features:

1. Original contours at not more than 5 feet intervals.

2. Existing drainage components, i.e., streams, ponds, watershed boundary, etc.

3. Property boundary lines.

4. Existing streets, buildings and utilities.

5. 100 year flood line and floodway or building restriction floodlines, where applicable.

6. Off-site drainage entering the site.

7. Mylar original no larger than 24-inch X 36-inch and at scale from 1 inch equals 10 feet to 1 inch equals 50 feet.

8. Where City/County topographic maps or other available topographic information is used, sufficient checks shall be provided to ensure the accuracy of the topo graphic maps.

C. Site Plan:

1. Existing and proposed structures, roads, buildings, paved areas.

2. Existing and proposed stormwater management system and components including sizes, lengths, pertinent elevations, etc.

3. Where and how proposed stormwater management system will be connected to existing systems.

4. Location and grade of all swales including cross section.

5. Proposed erosion control measures.

6. Existing and planned ground cover.

7. Typical street cross sections, **in subdivisions**.

8. Total impervious area in square feet (existing and planned).

9. Limits of work showing areas to be disturbed and areas to remain undisturbed and noting square footage of the areas to be disturbed.

10. Construction specifications.

11. Control release facilities showing cross-sections and profiles.

D. Final as-built plans to be submitted in Auto-Cad DXF or DWG file format.

2. Design Backup:

A. Calculations of runoff (pre-development and post development).

B. Calculations for stormwater detention/retention facility and other system elements. See applicable sections for detailed submission requirements.

C. Operation and Maintenance Manual for private stormwater control facilities.

3. Certification Requirements:

The following certifications shall appear on all plans:

"I hereby certify that this plan has been prepared in accordance with the City of Asheville Stormwater Standard Specifications Manual".

Signature: ____

Printed Name and Title: ______________________________________

Date: ____________________

8.03 STORMWATER IMPOUNDMENTS

Retention (wet) facilities **may** be utilized where the upstream drainage area is ten (10) acres or greater. Detention (dry) facilities shall be utilized where the upstream drainage area is less than ten (10) acres.

Impoundments shall be designed in accordance with Section 8.04.

In addition, the following guidelines should be followed when designing wet ponds:

1. Side slopes shall be no steeper than 3:1 and no flatter than 10:1.

2. **Both barrel and riser shall be located in or near the embankment.**

3. The riser inlet shall be covered with a trash rack to prevent clogging.

4. A maintenance access shall be provided via a minimum ten (10) foot wide gravel road in a minimum twenty (20) foot wide maintenance access easement or public right of way. The road shall be adequate to withstand heavy equipment. The access road shall not cross the emergency spillway, and shall have a maximum slope of 5:1.

5. The design shall include a minimum twenty (20) foot maintenance easement around the perimeter of the basin and dam structure.

6. On-site disposal areas capable of receiving sediment from at least two (2) clean-out cycles should be reserved in adjacent open space, if available.

7. The outlet channel shall be protected by an appropriately designed velocity dissipater.

8. The embankment shall allow for a minimum one (1) foot freeboard.

9. Anti-seep collars shall be installed around the barrel and a core trench shall be installed under the embankment to key it to the substrate.

10. Retention facilities may be used as erosion control devices during construction upon approval by the Erosion Control Engineer.

11. The City shall receive, for all stormwater impoundments, design calculations including, but not limited to, hydrographs, routing and outlet sizing.

12. The pond should have a water supply other than surface runoff.

13. The side of the pond at the water's edge should be as vertical and as free of vegetation as possible. A minimum depth of 18 inches of water is recommended at the edge.

14. A minimum depth of 6 feet is needed to prevent the emergence of vegetation and allow for siltation. A 2:1 slope is recommended.

15. Side slopes must be stabilized with a grass seed able to survive inundation and dry periods. The side angle must be shallow enough to permit mowing and to allow access to the basin floor.

16. Access to the basin shall be prevented by a six foot high chain link fence with a locked entrance gate. Gate is to be wide enough to allow mowing and maintenance equipment to enter the site. A minimum distance of 25 feet between the pond edge and fence is needed to permit future de-silting operations. However, one objective of retention basin design could be to eliminate the need to fence the final facility. Fencing limits any multiple use and aesthetic value the retention basin may have had. The key to not fencing retention facilities is the design of specific safety measures to make basins reasonably safe under the full range of storm water conditions if is likely to encounter.

17. A secondary outlet capable of the handling the 50 year discharge such as a weir or standpipe is to be provided in the event that the primary outlet clogs during a storm or the design storm is exceeded.

18. Outlet channels between the basin outlet and the discharge stream should be designed to prevent erosion, siltation and standing water.

19. A trash catching devise is to be installed on all outlets and such is to be easily accessible for removal of collected debris.

20. The control structure release rate shall be based upon the pre-development peak runoff rates for the 2 year and 10 year storms.

21. Design and construction are required to demonstrate that the facility will limit the 2 and 10 year developed discharge rates to pre-developed peaks discharge rates.

8.04 DETENTION BASIN DESIGN

1. A grassed or concrete lined low flow channel is to be constructed across the basin from the inlet to the outlet structure so that the basin contains no standing water five days after the end of a storm.

2. A concrete apron is to be poured at each inlet to prevent soil erosion from forming a pocket.

3. The entire basin is to be sloped towards the outlet and towards the low flow channel. On a grassed floor a 1.5 to 2.0 percent slope is needed.

4. A grassed floor must be on soil firm enough to support the weight of mowing equipment.

5. Side slopes must be stabilized with a grass seed able to survive inundation and dry periods. The side angle must be shallow enough to permit mowing and to allow access to the basin floor.

6. Access to the basin can be prevented by a six foot high chain link fence with a locked entrance gate. Gate is to be wide enough to allow mowing and maintenance equipment to enter the site. A minimum distance of 25 feet between the pond edge and fence is needed to permit future de-silting operations.

   However, one objective of detention basin design could be to eliminate the need to fence the final facility. Fencing limits any multiple use and aesthetic value the detention basin may have had. The key to not fencing detention facilities is the design of specific safety measures to make basins reasonably safe under the full range of storm water conditions it is likely to encounter. **A safety ledge and a flat shore line (4:1) are required as a minimum in addition to a maximum depth in the basin of 4 feet in order to not provide a fence around the detention basin.**

7. A trash catching devise is to be installed on all outlets and such is to be easily accessible for removal of collected debris.

8. An emergency outlet capable of handling the 50 year discharge such as a weir or standpipe is to be provided in the event that the primary outlet clogs during a storm or the design storm is exceeded.

9. Outlet channels between the basis outlet and the discharge stream should be designed to prevent erosion, siltation and standing water.

10. The control structure release rate shall be based upon the pre-development runoff rates for the 2 year and 10 year storms.

11. Design and construction are required to demonstrate that the facility will limit the 2 and 10 year developed discharge rates to pre-developed peaks discharge rates.

The following text is derived from a technical paper by the North Carolina Department of Environmental Management. The content of the paper has been revised to more specifically address requirements of the City of Asheville.

<u>AN OVERVIEW OF WET DETENTION BASIN DESIGN</u>

The design of wet detention basins is based on retaining the runoff from a storm for an extended length of time in order to settle out suspended solids and pollutants (such as heavy metals and nutrients). Biological treatment also occurs. Driscoll's model was chosen for the permanent pool water quality component of the design. The model uses as input a long-term average storm statistically calculated from the historical rainfall record. By using this storm and the appropriate watershed characteristics (e.g., impervious cover), a permanent water quality pool is sized to detain the runoff long enough to attain the target total suspended solids (TSS) removal. The model incorporates settling that occurs during the storm (dynamic) and between storms (quiescent). The movement of the storm runoff through the basin is assumed to be via plug flow. In general, the City requires 85% TSS removal in basins designed for the long-term average storm. This may be achieved by detaining runoff from the first 1-inch of rainfall for not less than two (2) days and not more than five (5) days.

In addition to the permanent water quality pool, the basin should have a temporary water quality pool for extended detention. This temporary water quality storage, located above the permanent pool, is necessary for periods when runoff entering the basin is significantly warmer than the permanent water quality pool. During these periods, a thermocline is established, plug flow does not occur and runoff exits the basin without being detained long enough to achieve maximum settling. To counteract this lack of detention and time settling, the runoff (from 1-inch storm) should be slowly released through a negatively sloped pipe. (Figure 1)

Once the minimum surface area and temporary storage volume of the basin needed to achieve the stated water quality goals are determined, the principal outlet and emergency spillway may be sized for flood detention for pre-development flow or erosion control. The storage allocated to flood control is located on top of both water quality pools, while the storage for erosion control occupies the same storage as the temporary water quality pool. (Figure 1)

The wetted perimeter of the basin should be planted with aquatic vegetation. This vegetation not only enhances pollutant removal but provides wildlife and waterfowl habitat, and protects the shoreline erosion.

The basins should be sized for the entire contributing area including offsite drainage. In general, instream impoundments should not be installed in order to avoid sizing the storage for the entire upstream watershed. If a development encompasses the entire upper part of a drainage area, then locating the basin in the streambed will not increase the required storage. If the development has offsite drainage flowing onto the site several basins may be utilized and sized for smaller drainage areas.

In addition to being properly designed, the basin must also be routinely maintained to satisfy long-term water quality goals. A key to any maintenance program is the allocation of adequate funding and the designation of the responsible party.

SURFACE AREA TO DRAINAGE AREA RATIO (SA/DA) FOR PERMANENT POOL SIZING FOR 85% POLLUTANT REMOVAL EFFICIENCY

TABLE 1

IMPERVIOUS %	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
10	0.59	0.54	0.49	0.47	0.43	0.39	0.35
20	0.97	0.88	0.79	0.75	0.70	0.65	0.59
30	1.34	1.20	1.08	1.03	0.97	0.91	0.85
40	1.73	1.58	1.43	1.36	1.25	1.14	1.03
50	2.00	1.82	1.73	1.64	1.50	1.40	1.33
60	2.39	2.09	2.03	1.87	1.66	1.56	1.51
70	2.75	2.44	2.27	2.12	1.96	1.87	1.79

<u>Using the Chart</u>

The numbers in the chart represent surface area (SA) to drainage area (DA) percentages. SA = the wet detention pond permanent pool surface required for 85% pollutant removal. The chart is based on the amount of impervious cover as a percentage of the area draining to the pond and the depth of the permanent pool of the pond. Impervious percentages are in the left hand column of the chart and depths are given across the table from 3 feet to 6 feet in half foot increments.

To determine the required permanent pool size use the following steps:

1. Calculate the percent impervious cover of the site draining the pond (amount of impervious area/total site area).

2. Determine the permanent pool depth (or select a depth for comparison purposes).

3. Go to the above chart with the impervious percentage found in 1. Go across the chart at this impervious percentage until you are under the appropriate permanent pool depth and read the value in

the table. The number in the chart is given as a percentage (%). If your impervious percentage or pond depth is between one of the value given you can interpolate between values.

4. To determine the required surface area of the pond take the number from the chart, divide by 100 and multiply this number by the contributing drainage area.

   For example: assume a 10 acre site with 3 acres of impervious cover.

   1. % impervious = 3/10 = .30 or 30%.

   2. assume a 4 foot permanent pool depth.

   3. From the chart, with 30% impervious and 4 foot depth, the SA/DA ratio is given as 1.08.

   4. So the required surface area of the permanent pool is: (1.08/100) * 10 = .108 acres or 4,705 square feet.

   5. The design runoff volume to be controlled must then be held in the pond above this permanent pool level.

   6. The embankment shall allow for a minimum one (1) foot freeboard.

   7. Anti-seep collars shall be installed around the barrel and a core trench shall be installed under the embankment to key it to the substrate.

   8. Retention facilities may be used as erosion control devices during construction unless otherwise approved by the City Engineer.

   9. The City shall receive, for all stormwater impoundments design calculations including, but not limited to, hydrographs, routing and outlet sizing.

DESIGN OF PERMANENT POOL DETENTION BASINS

A. <u>Design for Water Quality Control</u>

a) For the permanent water quality pool, use basin surface area/drainage area (SA/DA) ratios for given levels of impervious cover and basin depths (Table 1).

b) Average permanent water quality pool depths should be between 3 and 6 feet.

c) Use impervious levels expected in the final stages of development.

d) Locate the temporary water quality pool for extended detention above the permanent water quality pool. The orifice of the negatively sloped pipe should be sized to release runoff from the first 1-inch rainfall over a period between 48 to 120 hours.

e) Basin shape should minimize dead storage areas: average length of flow to effective width > 2.0.

f) A forebay (may be established by a weir) should be included to encourage early settling. This allows drainage of only one portion of the basin in order to excavate accumulated sediment. The forebay volume should equal only 20% of the basin volume (Figure 2).

g) Check area

h) If the basin is used as a sediment trap during construction, make sure all sediment deposited during construction is removed before normal operation begins.

I) Aquatic vegetation should be included for a wetland type detention basin. A minimum 10 foot wide, one foot deep shelf is required around the edge of the basin for safety and to provide appropriate conditions for aquatic vegetation establishment. This shelf should be sloped 6:1 or flatter and extend out to a point 2 to 2.5 feet below the surface. A list of suitable wetland species and propagation techniques are provided in Schueler (1987) and Maryland DNR (1987).

j) An emergency drain (with a pipe sized to drain the pond in less than 24 hours) should be installed in all ponds to allow access for riser repairs and sediment removal.

B. <u>Design For Water Quantity</u>

a) <u>Design Storm</u>

1) The primary outlet will most likely be designed for a 10-year storm. SCS suggests using the 6-hour storm.
2) The emergency spillway should be designed for the 50-yr storm. The Dam Safety Act gives guidance on design storms for spillways in larger basins.
3) Note that storms of other duration's should be checked for overtopping.

b) <u>Peak Runoff Flow</u>

** 1) Use the SCS method, or

2) Use the Rational method (especially for watersheds less than 200 acres).

* Note: Care should be taken with either method to accurately calculate the Curve Number of Rational C.

**If the SCS method for calculating the runoff produces less than 0.5 inches of runoff, an alternate method for calculating runoff shall be used.

c) <u>Volume of Runoff, Hydrograph Shape and Storage Required</u>

1) Follow procedures in Malcom, <u>et</u> <u>al</u>., 1986, pp. 61-65, or

** 2) Use SCS Methods.

3) Be sure to include a sediment storage pool in <u>addition</u> to the water quality and flood pools. Unfortunately there is only limited data on sediment yields from urban areas. A method outlined in Schueler (1987, pp. 1.9-1.20) may be used for predicting those sediment yields. See examples 1-2 on page 2.19. In Piedmont areas, (P) = 42 inches per year and (Pj) = 0.9 (estimated). This calculation is for stabilized areas. The designer should keep in mind that this average sediment yield is at best an <u>estimate</u> of the actual sediment yield which is extremely dependent on such factors as soil type, slope and vegetative and stabilization practices. The designer would be prudent to overestimate sediment yield since more conservative (i.e., higher) sediment yield estimates will result in a larger allocated sediment storage and less frequent clean outs.

d) <u>Stage-Storage Function for Basin</u>

See Malcom and New, 1975, pp. 106-109.

e) Stage Discharge

1) See appropriate equations for outflow structures and when each equation is the limiting factor (Barfield, et al., 1981, pp. 227-236; Malcom and New, 1975, pp. 3-9 to 3-11), or

2) Use methods in Land Quality's Sediment Basin handout (NCDNRCD, Land Quality, 12/86, pp. 5).

f) Emergency Spillway and Dam Height

1) Use SCS methods for emergency spillway design (Engineering Field Manual, USDA, SCS, 1986, Chapter 11; NCDNRCD, Land Quality, 12/86).

2) Include calculation for wave height and wind setup for a detailed freeboard analysis (Lindsley and Franzini, 1972, pp. 1790-183).

3) Dams 15 feet or higher with an impoundment capacity of 10-acre-feet or greater at the top of the dam must obtain a Dam Safety permit from NCDNRCD, Land Quality.

g) Storm Routing

1) Use either Storage Indication Method (Viessman, et al., 1977, pp. 240-244; Malcom and New, 1975, pp. 113-115; Sec. 4, Chapter 17), or

2) Use HRM (H.R. Malcom) method of routing which is easy to execute and approximates the Storage-Indication Method (Malcom and New, 1975, pp. 3-2 to 3-6, 110-113, or

3) Use SCS TR-20 method of routing.

4) The TR-55 routing method may be used for preliminary design (USDA, SCS, 1986, TR-55, pp.7-6 to 7-13).

h) Downstream Protection

1) As required in the Sedimentation Control Plan (NCDNRCD, 8/1/85, Title 15, MCAC 4B.0009). The post-construction velocity of the 10-year storm runoff shall not exceed the greater of:

a) the maximum permissible velocity for the given channel lining,

b) the 10-year development velocity.

2) Use methods in N.C. Division of Land Quality's Energy Dissipater handout (no date).

3) As mentioned in A (c) above, release the runoff from the first one-inch of rainfall over a 48 hours period for temporary water quality control. McCuen and Moglen's research (1987) as well as search reviewed by Schueler (1987) suggest that smaller storms are the key to controlling downstream streambank erosion. Schueler (1987) suggests that runoff from the first one-inch of rainfall released over 24-40 hours can reduce downstream erosion. Therefore the design and storage pool for erosion control shall be the same as that for the temporary water control.

I) <u>Construction of Basin and Dam</u>

1) See SCS Technical Guideline #378-1, Ponds.

2) See guidelines in Dam Safety Act (NCDNRCD, 11/1/85) and SCS handbook (USDA, SCS, 1986, Chapters 11 and 17).

3) See estimated construction costs from the NURP project in Washington COG, 1983, Chapter 3).

4) Facilities with a large amount of oil and grease should use an oil and grease skimmer.

5) Stormwater should be routed via grassed waterways or pipes to the upper part of the basin to reduce short circuiting and obtain maximum detention time and settling.

C. <u>Operation and Maintenance</u>

Operation, maintenance and annual inspections shall be performed as outlined in the City of Asheville Ordinance Sections pertaining to Operation and Maintenance.

D. <u>Location</u>

a) In order to avoid sizing the basin for the entire upstream drainage area, basins should be located out of the streambed and sized for smaller subbasins in the development. Particular care should be taken to modify storm drainage so that all developed areas drain to the basin especially if the site is intensively developed (e.g., condominium or commercial). This method will assure that runoff from impervious areas will be treated, without the necessity of retreating upstream runoff.

b) In newly developed areas of the watershed, a regional detention basin may be an option for the local government and developers to consider. Compensation and joint maintenance contracts between upstream and downstream property owners would probably be necessary.

c) Buffers around the basin should be determined by the flood pool (usually the 100-year storm).

E. Certification

All basins should be designed, stamped, and certified that they are built as designed by a N.C. registered professional engineer.

F. Definitions

1) Forebay - The forebay is an excavated settling basin or section separated by a low weir at the head of the primary impoundment. The forebay serves as a depository for a large portion of sediment and facilitates draining and excavating the basin.

2) Plug flow - Fluid particles pass through the basin and are discharged in the time equal to the theoretical detention time. This type of flow is length-to-width ratios.

3) Primary outlet - The primary outlet is often constructed of a riser/barrel assembly and provides flood protection (i.e., for the 10-yr. storm) or reduces the frequency of the operation of the emergency spillway.

4) Emergency spillway - The emergency spillway is designed to discharge flow in excess of the principal spillway design discharge (i.e., safely pass the 100-year storm).

5) Impervious surface - Surfaces providing negligible infiltration such as pavement, buildings, recreation facilities, etc.

END OF SECTION 8.00